Chemicals BestPractices Plant-Wide Assessment Case Study

Industrial Technologies Program

Formosa Plastics Corporation: Plant-Wide Assessment of Texas Plant Identifies Opportunities for Improving Process Efficiency and Reducing Energy Costs

Benefits

- Identified potential annual fuel savings of 115,000 MMBtu and annual electricity savings of 14 million kWh
- Found potential annual cost savings of $1.5 million
- Identified ways to increase productivity and reduce waste and environmental emissions

Application

This plant-wide assessment combined a practical minimum energy use methodology with industry benchmark metrics to determine how to improve selected chemical processes and determine the best ways to reduce the plant's energy requirements.

Summary

At Formosa Plastics Corporation's plant in Point Comfort, Texas, a team completed a plant-wide assessment designed to review and analyze process energy requirements, review new technologies for applicability, and improve overall energy efficiency. The assessment team identified the energy requirements of each production process and then compared actual energy consumption with theoretical process requirements. This information was used to identify process modifications that could improve energy efficiency. If all projects identified during the Point Comfort plant study were implemented, the assessment team estimated that total annual energy savings would be about 115,000 MMBtu for natural gas and nearly 14 million kWh for electricity. Total annual cost savings would be about $1.5 million.

Public-Private Partnership

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) cosponsored the assessment through a competitive process. DOE promotes plant-wide energy-efficiency assessments that will lead to improvements in industrial energy efficiency, productivity, and global competitiveness while reducing waste and environmental emissions. In this case, DOE contributed $100,000 of the total $242,000 assessment cost.

Plant Description

Formosa Plastics Corporation, U.S.A., and its subsidiaries manufacture and supply plastic resins and petrochemicals for a multitude of products and processes. Formosa selected its linear low-density polyethylene (LLDPE) plant in Point Comfort, Texas, as the subject of a plant-wide energy efficiency assessment because the LLDPE plant consumes more energy than any other unit in the corporation.

The LLDPE plant manufactures polyethylene pellets that downstream customers use to produce consumer products such as plastic housewares, containers, and toys. The primary production process is polymerization, which converts ethylene into useful and stable polyethylene powder. The polyethylene powder is then mixed with additives and fed into an extruder, where the powder is heated and forced through a die to make plastics pellets. The plastics pellets are then transferred to railcars or trucks and/or packaged in bags and shipped to customers. The major utilities that this plant requires are electricity, water, natural gas, nitrogen, and steam.

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

The plant's LLDPE process units include the following.

Catalyst Preparation Unit (CPU)—The catalyst is prepared in a reactor in a batch process that features sequence-controlled charging of the reagents and the reaction.

Prepolymerization Unit (PPU)—The catalyst prepared in the CPU is converted into prepolymer in the prepolymerization reactor. After reaction, the prepolymer is dried, stored, and conveyed by nitrogen to an injection system. Metering of the catalyst, reaction, and drying are sequence-controlled batch processes.

Polymerization Unit (PU)—The comonomer and the prepolymer from the PPU are introduced into a fluidized bed reactor, where the continuous polymerization reaction takes place. The fluidizing process gas circulates in a reaction loop; this step removes entrained powder. The gas is cooled and then compressed before it re-enters the reactor by means of a gas compressor. A lateral withdrawal system removes the powder polymer product. The powder is pneumatically conveyed to an Additives and Pelletizing Unit after the hydrocarbon is removed.

Additives and Pelletizing Unit (APU)—The powder from the PU and the powdered masterbatch are fed together to the extruder for pellet production. The masterbatch is prepared by blending special additives with virgin powder, and it is added separately to the extruder feed chute. Rerun pellets and pelletized masterbatch can also be fed, if required. Pellets are carried away by a pelletizing water circuit, dried, screened, and pneumatically conveyed to the Product Storage Unit.

Product Storage Unit (PSU)—The pellets from the APU are blended in homogenization silos. Transition silos are used to accommodate grade changes. The pellet product is then conveyed pneumatically to storage silos; later, it is loaded into hopper cars or bags for shipment to customers.

Assessment Approach

The energy assessment team was made up of staff from the Point Comfort plant's operations and engineering departments and staff from a consulting firm, BRIDGES to Sustainability. BRIDGES to Sustainability developed two decision tools used in the assessment. First, team members used benchmark data to calculate sustainability metrics that identified the energy intensity (kWh required per pound of product) for each process area.[1] Second, they calculated practical minimum energy (PME) requirements through a pinch analysis and a fluid-handling analysis, which determines the amount of energy needed to compress and transfer liquids from one part of a process to another. The team used the PME to determine the minimum energy requirements for LLDPE production processes.

The team systematically applied the PME methodology to determine how the energy requirements of selected chemical processes could be improved if specific types of process improvements and investment criteria are used. To determine the economic feasibility of an improvement, team members calculated the return on investment and payback periods for selected projects, taking into account Formosa's internal requirement for a 2- to 3-year payback on capital investments. To review and analyze process requirements, research new technology, and determine whether more energy-efficient equipment could be incorporated into the LLDPE process, the assessment team took the following actions.

- Evaluated the efficiency of various kinds of equipment to identify those that consumed the most electricity
- Identified the energy requirements of each process step
- Compared actual energy consumption with theoretical process requirements
- Reviewed and analyzed operating procedures to determine whether sequential instructions could be modified to improve process efficiency.

[1] Benchmark data are from Phillip Townsend Associates, Inc., for energy use in LLDPE production. BRIDGES to Sustainability compared the benchmark data and LLDPE plant data to establish sustainability metrics for LLDPE on energy intensity.

Results and Projects Identified

This plant-wide assessment resulted in six projects that could save energy, increase productivity, and reduce waste and environmental emissions. These projects are summarized in Table 1 and then explained in more detail.

Table 1. Projects Identified During Formosa's LLDPE Plant-Wide Energy Assesment

	Projected Energy Savings		Economic Impact		
Project	Fuel Savings (MMBtu/yr)	Electricity Savings (kWh/yr)	Annual Cost Savings	Capital Cost	Payback Period (yr)
Upgrade gas compressor impeller	NA	8,344,000	$333,760	$700,000	2.1
Improve product transfer system	NA	3,344,000	$133,760	$100,000	0.7
Improve extruder system heating	NA	1,488,000	$59,520	$4,000	0.1
Optimize vent blower system	NA	896,000	$35,840	$14,500	0.4
Recover steam condensate	5,600	NA	$56,000	$75,000	1.4
Recover vent gas nitrogen	109,538	NA	$877,000	$2,000,000	2.3
Totals	**115,138**	**14,072,000**	**$1,495,880**	**$2,893,500**	**1.9 aggregate average**

Upgrade the gas compressor impeller

During a review of the primary rotational equipment used in LLDPE, the assessment team found that the gas compressor used a significant amount of energy. The compressor is used to recover ethylene discharged from the polymerization reactor along with polyethylene. The team found that a new, open-type impeller design would be suitable for the gas compressor (Figure 1). They determined that the existing closed-type impeller used 14% more electricity than an open-type impeller under the same operating conditions. The new impeller design would improve efficiency and reduce the possibility of polyethylene buildup, which can cause blockages and reduce operating efficiency.

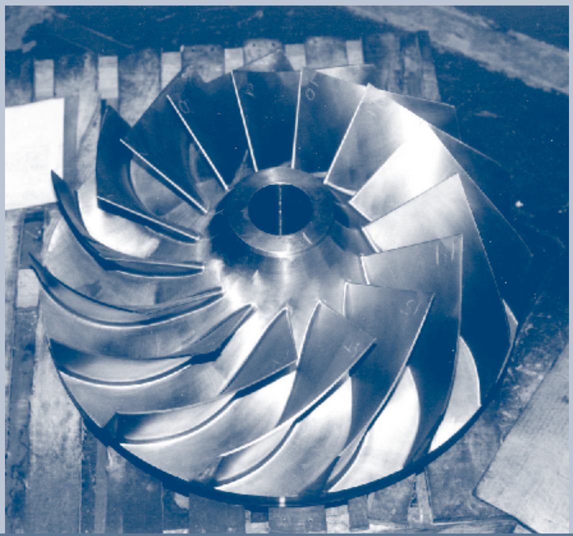

Figure 1. New open-type impeller design

Improve the product transfer system

In studying the product transfer system's equipment and operation, the team determined the energy requirements of 14 blowers used to transfer LLDPE resin through various manufacturing process steps. Combined, the 14 blower motors are rated at 3,500 horsepower (hp) and are used in transferring product for blending, storage, and railcar loading. Because these processes require a significant amount of electricity, the team recommended two options for reducing electricity consumption. The first option was to increase the transfer rate, thus reducing the total time required to transfer product. The second was to reduce the idle time between product transfers through production control and distributive control system monitoring. Electricity cost savings resulting from the second option were estimated to be $133,760 per year. Formosa decided that, ultimately, both options will be implemented. The first is already being carried out in one area of product transfer; the second will be implemented after the first is successfully completed.

Improve extruder system heating

The first four sections of the extruder system are designed to melt the powder fed into the extruder. An electric heating element with a water-cooling system maintains the correct melting temperature. The assessment team found that the cooling water flow and the heating element temperature were not optimal for operating efficiency or for maintaining the set temperature. In reviewing heating and cooling requirements and operation sequencing, the team found that the cooling manifold was reducing the temperature of the extruder at the same time that an electric heating element was sending more heat to the extruder than necessary. The team therefore developed a plan to improve control of the heating element, reduce its temperature range, and upgrade the cooling water manifold.

Optimize the vent blower system

The vent blower system collects volatile organic compounds (VOCs) that are removed from the polyethylene resin during drying. The VOCs are transferred to an incinerator, where they are burned to reduce air emissions. During a historical data review and field operation check of the system, the team found that a much smaller system would meet venting requirements. Therefore, a smaller vent blower system was installed and is already providing energy cost savings of $35,840 per year.

Recover steam condensate

Steam provides the heat needed for the LLDPE production process. The Point Comfort plant was originally designed to discharge steam condensate into the cooling tower as a source of cooling tower makeup water. Water used to produce steam must be demineralized before it is fed to boilers or other steam-producing devices.

The energy assessment team proposed two options for recovering this high-purity condensate water: (1) divert the condensate stream to the waste heat boiler as a supplemental source of pure feed water, or (2) direct the condensate to the pelletizing process as pure makeup water, because water is used to cool the pellets produced by the extruder. With an investment of $40,000, option 2 would yield savings of $35,000 per year; however, this option would require additional energy to cool the steam condensate before its use as makeup for the pelletizing process. Therefore, the team selected option 1, which would transfer steam condensate to the high-density polyethylene plant's waste heat boiler for use as pure feed water makeup. This would save $56,000 annually—$35,000 per year for pure feed water makeup for the waste heat boiler and $21,000 for natural gas, as a result of using the residual energy recovered from the steam condensate. The steam condensate recovery project will also reduce the amount of pure water required in the extrusion area. Recovering and recycling steam condensate allows the plant to reduce the amount of pure water it must purchase.

Recover vent gas nitrogen

The LLDPE resin produced in the reactors contains residual ethylene, which is removed by using nitrogen as a carrier gas. The streams containing residual ethylene that cannot be recycled back into the process are sent to an incinerator, which burns the residual ethylene to minimize contamination of the air. Two nitrogen-rich (≈99% nitrogen) waste streams discharge vent gas to the incinerator. The assessment team evaluated the potential for recycling this nitrogen back to the process, thus reducing the need for incineration and for releasing nitrogen to the environment. An added benefit would be making more nitrogen available for use in other parts of the facility.

Potential annual cost savings would be $877,000—$521,000 for nitrogen and $356,000 for natural gas. However, the absorption technology for purifying these waste streams is not yet mature. Therefore, Formosa staff members continue to search for better technologies for this project.

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste

BestPractices is part of the Industrial Technologies Program, and it supports the Industries of the Future strategy. This strategy helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and energy-management best practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

Project Partners

Formosa Plastics Corporation
Point Comfort, TX

BRIDGES to Sustainability
Houston, TX

For Additional Information, Please Contact:

EERE Information Center
1-877-EERE-INF
(1-877-337-3463)
www.eere.energy.gov

Visit our home page at
www.eere.energy.gov/industry

Industrial Technologies Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy
Washington, DC 20585-0121

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

DOE/GO-102005-2062
January 2005